GRADE 12 DIPLOMA EXAMINATION

Physics 30

January 1989

Alberta
EDUCATION

GRADE 12 DIPLOMA EXAMINATION
PHYSICS 30

DESCRIPTION

Time: 2½ hours

Total possible marks: 70

This is a **CLOSED-BOOK** examination consisting of two parts:

PART A: 49 multiple-choice questions each with a value of 1 mark.

PART B: Four written-response questions for a total of 21 marks.

A physics data booklet is provided for your reference. Approved calculators may be used.

GENERAL INSTRUCTIONS

Fill in the information on the answer sheet as directed by the examiner.

For multiple-choice questions, read each carefully and decide which of the choices BEST completes the statement or answers the question. Locate that question number on the answer sheet and fill in the space that corresponds to your choice. **USE AN HB PENCIL ONLY.**

Example

This examination is for the subject area of

A. Chemistry
B. Biology
C. Physics
D. Mathematics

Answer Sheet

A	B	C	D
①	②	●	④

If you wish to change an answer, please erase your first mark completely.

For written-response questions, read each carefully, show all your calculations, and write your answer in the space provided in the examination booklet.

NOTE: The perforated pages at the back of this booklet may be torn out and used for your rough work.

DO NOT FOLD EITHER THE ANSWER SHEET OR THE EXAMINATION BOOKLET

The presiding examiner will collect the answer sheet and examination booklet for transmission to Alberta Education.

JANUARY 1989

PART A

INSTRUCTIONS

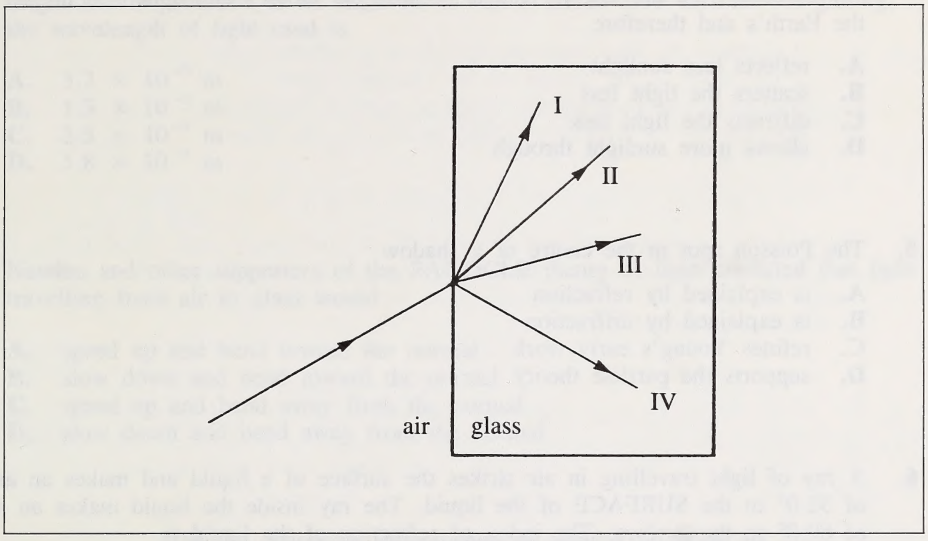
There are 49 multiple-choice questions with a value of one mark each in this section of the examination. Use the separate answer sheet provided and follow the specific instructions given.

NOTE: The perforated pages at the back of this booklet may be torn out and used for your rough work.

WHEN YOU HAVE COMPLETED PART A, PROCEED DIRECTLY TO PART B

DO NOT TURN THE PAGE TO START THE EXAMINATION UNTIL TOLD TO DO SO BY THE PRESIDING EXAMINER

Use the following information to answer question 1.



1. The most probable refracted ray is represented by path

A. I
B. II
C. III
D. IV

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2. Light passes through two slits separated by 5.0×10^{-4} m and produces an interference pattern on a screen 2.5 m away. If the first-order bright line is located 3.5×10^{-3} m from the central maximum, the wavelength of the light is

A. 4.0×10^{-7} m
B. 7.0×10^{-7} m
C. 4.0×10^{-4} m
D. 7.0×10^{-1} m

3. The incident light rays from the sun are parallel as they strike the surface of a plane mirror. The reflected rays

A. scatter
B. diverge
C. converge
D. remain parallel

4. The sky as seen from the moon would be a different color from the color of the sky as seen from the Earth. This is because the moon's atmosphere is thinner than the Earth's and therefore

A. reflects less sunlight
B. scatters the light less
C. diffracts the light less
D. allows more sunlight through

5. The Poisson spot in the centre of a shadow

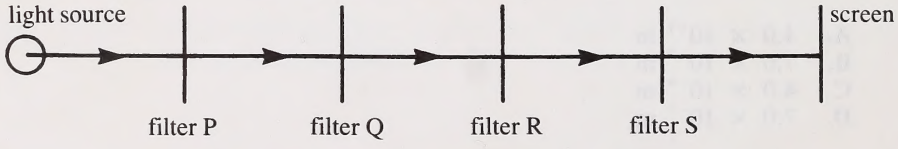
A. is explained by refraction
B. is explained by diffraction
C. refutes Young's early work
D. supports the particle theory

6. A ray of light travelling in air strikes the surface of a liquid and makes an angle of 32.0° to the SURFACE of the liquid. The ray inside the liquid makes an angle of 60.0° to the surface. The index of refraction of the liquid is

A. 0.59
B. 0.61
C. 1.63
D. 1.70

Use the following results to answer question 7.

A light source emits a mixture of blue, yellow, red, and infra-red radiation.



Filter P removes only ultraviolet radiation.
Filter Q removes only infra-red radiation.
Filter R removes only red radiation.
Filter S removes only blue radiation.

7. The color on the screen appears

A. black
B. white
C. green
D. yellow

8. Light is incident normally on a grating with 5.0×10^{5} lines/m. If the first-order bright line is produced at an angle of 15° on a screen 1.30 m from the grating, the wavelength of light used is

A. 5.2×10^{-7} m
B. 1.3×10^{-5} m
C. 2.3×10^{-5} m
D. 5.8×10^{-4} m

9. Newton and other supporters of the PARTICLE theory of light predicted that light travelling from air to glass would

A. speed up and bend toward the normal
B. slow down and bend toward the normal
C. speed up and bend away from the normal
D. slow down and bend away from the normal

Use the following information to answer question 10.

> The human eye sees many colors in an image on a color TV set, yet signals corresponding to only three colors are being sent.

10. The three signals being sent correspond to the colors

A. red, green, blue
B. red, yellow, blue
C. blue, cyan, green
D. cyan, magenta, yellow

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11. When total internal reflection occurs, the speed of the reflected light wave compared to the incident light wave will

A. increase
B. decrease
C. become zero
D. remain constant

12. If the distance between two charged spheres remains constant, and the charge on each sphere is doubled, then it can be predicted that the force between them will be

A. ¼ the original
B. ½ the original
C. 2 times the original
D. 4 times the original

13. Whenever a net charge is placed on a neutral object by contact, the predicted sign of the charge on the object

A. is opposite to the charge on the charging agent
B. is the same as the charge on the charging agent
C. returns to neutral once the charging agent is removed
D. depends on the kind of material making up the object

14. Two negatively-charged spheres placed 1.00 m apart repel each other with a force of 101 N. If the distance between the spheres is increased to 3.00 m and the charge on each sphere is increased by a factor of 4, the force of repulsion would be expected to become

A. 4.45×10^{1} N
B. 1.35×10^{2} N
C. 1.80×10^{2} N
D. 5.39×10^{2} N

15. Two small spherical clouds with charges of 1.0 C and 1.6 C repel each other with a force of 9.0×10^{2} N. The distance separating the centres of the spheres is

A. 4.0 km
B. 1.6 km
C. 0.40 km
D. 0.16 km

16. At a distance of 2.0 m from a $+8.0 \times 10^{-6}$ C charge, the magnitude and direction of the electric field will be

A. 3.6×10^{4} N/C, towards the charge
B. 3.6×10^{4} N/C, away from the charge
C. 1.8×10^{4} N/C, towards the charge
D. 1.8×10^{4} N/C, away from the charge

17. An astronaut who weighs 9.00×10^{2} N on Earth travels to Planet X, which has the same radius as Earth. If the mass of Planet X is 1.98×10^{30} kg and the mass of the Earth is 5.98×10^{24} kg, then the factor by which the astronaut's weight has changed is expected to be

A. 3.02×10^{-6}
B. 2.72×10^{-3}
C. 3.31×10^{5}
D. 1.10×10^{11}

18. Which of the following pairs of fields have equations of similar algebraic form to describe their intensity?

A. The electric field of a point charge and the gravitational field of a point mass

B. The magnetic field of a moving charge and the electric field of a point charge

C. The electric field of a point charge and the magnetic field of a current-carrying wire

D. The magnetic field of a current-carrying wire and the electric field between parallel plates

19. If a proton initially at rest is accelerated through a distance of 5.0×10^{-2} m in a uniform electric field of intensity 10.0 N/C, a subsequent measurement of its speed will be expected to give the result of

A. 1.0×10^{-4} m/s
B. 5.0×10^{-1} m/s
C. 9.8×10^{3} m/s
D. 9.6×10^{7} m/s

Use the following information to answer questions 20 and 21.

An electron gun has an accelerating potential of 5.80×10^{2} V, and the accelerated electrons follow an orbit of radius 0.163 m in a magnetic field of strength 5.00×10^{-4} T.

20. The numerical value of qBr in SI units is

A. 1.30×10^{-23}
B. 9.28×10^{-17}
C. 1.86×10^{-16}
D. 3.78×10^{-2}

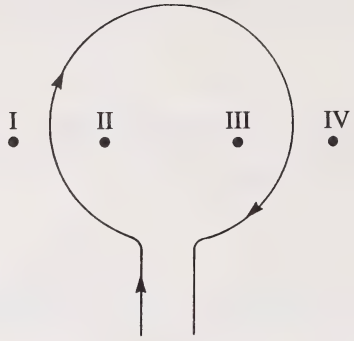
21. The product qBr has the same unit as does

A. energy
B. current
C. voltage
D. momentum

22. The unit representing the rate of flow of electric charge is the

A. volt
B. ohm
C. ampere
D. coulomb

Use the following diagram to answer question 23.



The diagram shows the direction of the flow of electrons in a current-carrying loop.

23. The magnetic field is directed into the plane of the page at points

A. I and II
B. I and IV
C. II and III
D. III and IV

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24. The BEST explanation of the Northern Lights is that they are produced by

A. electrostatic induction
B. reflection from the polar ice caps
C. rotation of the Earth's magnetic field
D. energetic particles in the Earth's upper atmosphere

25. A loop of wire is connected to a microammeter. When the loop is moved, the needle on the microammeter jumps. The MOST likely cause of this phenomenon is the presence of

A. an electric field in the room
B. a magnetic field in the room
C. an electric charge in the room
D. a magnetic charge in the room

Use the following information to answer question 26.

Hypotheses Concerning the Nature of Electromagnetic Waves

I. Electromagnetic waves carry energy.
II. Electromagnetic waves can be reflected.
III. Electromagnetic waves travel through space as changing electric and magnetic fields.
IV. Electromagnetic waves travel at different speeds in a vacuum depending on their frequency.

26. The hypotheses consistent with experimental data are

A. I and II only
B. II and III only
C. I, II, and III only
D. II, III, and IV only

Use the following information to answer question 27.

A radio signal is sent from city X to city Y by reflection from the ionosphere, which is 1.73×10^5 m above the Earth's surface. The signal is beamed from X and makes an angle of 60.0° with the ground. The distance from city X to city Y is 2.00×10^5 m.

27. If the effects of the curvature of the earth are neglected, the time it takes for the radio signal to reach city Y is

A. 5.57×10^{-4} s
B. 6.65×10^{-4} s
C. 1.15×10^{-3} s
D. 1.33×10^{-3} s

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28. If a car radio is approximately 75 cm from the nearest unshielded spark plug, the time interval between a spark in that plug and the corresponding noise on the radio will be in the order of magnitude of

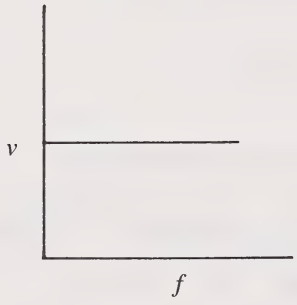
A. 10^{-9} s
B. 10^{-1} s
C. 10^{0} s
D. 10^{8} s

29. Microwaves with a wavelength of 3.0 cm pass through a diffraction grating that has a slit separation of 75 mm. The first-order maximum is produced at an angle of

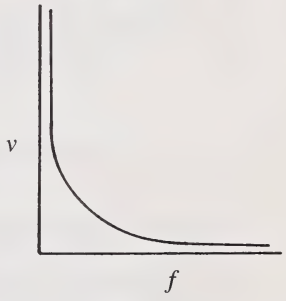
A. 53°
B. 24°
C. 2.3°
D. 1.2°

30. Which graph gives the relationship between the speed and frequency of electromagnetic radiation in a vacuum?

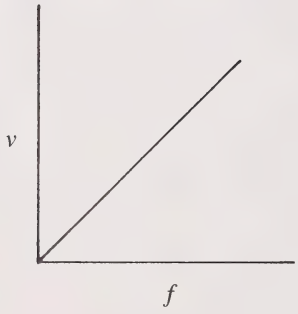
A.



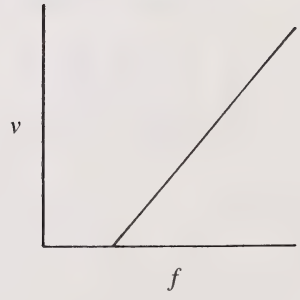
B.



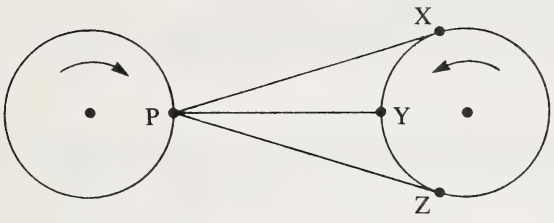
C.



D.



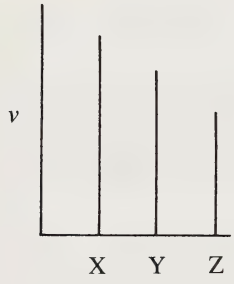
Use the following information to answer question 31.



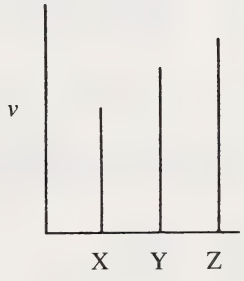
Two discs are rotating in opposite directions.

31. The graph that BEST illustrates the relative speeds of the light that reaches point P from points X, Y, and Z is

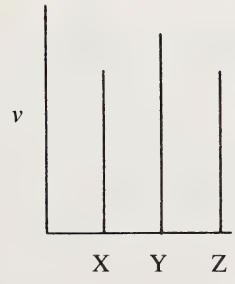
A.



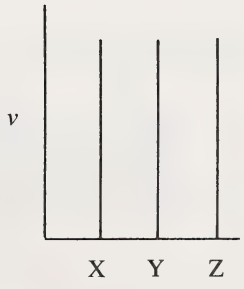
B.



C.



D.



32. An astronomer who observes the spectrum of an approaching star notices that the characteristic frequencies of the star's light have all increased (blue shift). This effect results from

A. an increase in the speed of the light
B. a decrease in the period of the light
C. a decrease in the frequency of the light
D. an increase in the wavelength of the light

33. An example of an electromagnetic wave with a frequency less than that of visible light is

A. X-ray
B. gamma
C. infra-red
D. ultraviolet

34. The ether concept was ORIGINALLY introduced to explain the

A. high speed of light
B. passage of light through outer space
C. existence of discrete photons in electromagnetic radiation
D. equality of speed of all forms of electromagnetic radiation in a vacuum

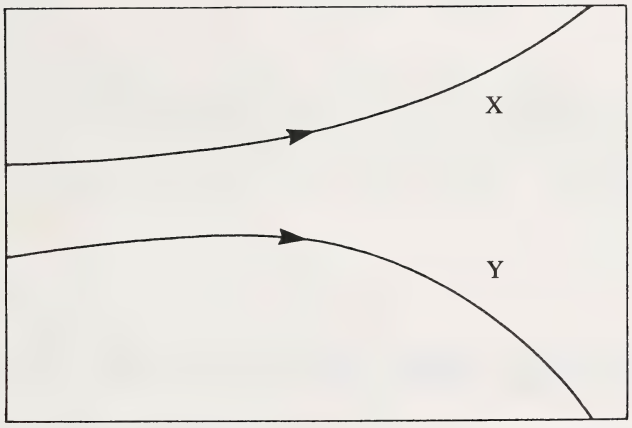
35. What current is required to deposit aluminum at a rate of 10.0 g/h in an electrolytic cell that is filled with a solution containing Al^{3+} ions?

A. 29.8 A
B. 33.7 A
C. 1.79×10^3 A
D. 1.07×10^4 A

36. Millikan was able to determine the charge of an electron by balancing which forces?

A. Electric and magnetic
B. Magnetic and centripetal
C. Electric and gravitational
D. Magnetic and gravitational

Use the following information to answer question 37.



This diagram shows the paths of two charged particles travelling from left to right perpendicular to a magnetic field.

37. A necessary conclusion from this diagram is that the particles

A. have different masses
B. travel at different speeds
C. have charges of opposite sign
D. have different amounts of charge

38. The mass-to-charge ratio m/q for a lithium ion is 7.25×10^{-8} kg/C and the charge on the lithium ion is 1.60×10^{-19} C. The mass of the ion is

A. 6.92×10^{-3} kg
B. 2.21×10^{-12} kg
C. 4.53×10^{-12} kg
D. 1.16×10^{-26} kg

39. A beam of electrons travels at 2.4×10^{6} m/s perpendicularly through a magnetic field of magnitude 1.3×10^{-4} T. The radius of curvature of the path is

A. 0.075 m
B. 0.11 m
C. 0.15 m
D. 0.25 m

40. In order to confirm Einstein's theory of the photoelectric effect, Millikan found Planck's constant from the slope of a graph of

A. photoelectric current as a function of frequency
B. stopping voltage as a function of wavelength
C. maximum E_k as a function of frequency
D. mass as a function of speed

41. According to the Bohr model, the ratio of the radius of the fifth hydrogen orbit to the radius of the second hydrogen orbit is

A. 25:4
B. 25:9
C. 5:2
D. $\sqrt{5}:\sqrt{2}$

42. The Balmer series was the first series in the hydrogen spectrum to be observed. It was observed first because the lines

A. have higher intensities than the lines in other series
B. are produced by electrons falling into the lowest energy level
C. extend into the visible region of the electromagnetic spectrum
D. are not as narrow as the lines produced by higher-energy transitions

43. An atom can gain energy in amounts approximately equal to 7.6×10^{-19} J, 1.10×10^{-18} J, and 1.70×10^{-18} J. If an electron hits the atom with 1.00×10^{-18} J of kinetic energy, the electron could rebound with kinetic energy equal to

A. 7.0×10^{-20} J
B. 2.4×10^{-19} J
C. 6.6×10^{-19} J
D. 7.6×10^{-19} J

44. An electron initially at rest experiences an unbalanced constant force and accelerates to a relativistic velocity. Which quantity associated with the electron remains unchanged?

A. Mass
B. Charge
C. Force-to-mass ratio
D. Charge-to-mass ratio

45. An object's relativistic mass is four times its rest mass. The speed of the object is

A. 2.6×10^{8} m/s
B. 2.7×10^{8} m/s
C. 2.8×10^{8} m/s
D. 2.9×10^{8} m/s

46. The momentum of a photon is related to the frequency of light by

A. direct proportionality
B. inverse proportionality
C. direct square proportionality
D. inverse square proportionality

47. An alpha particle with a speed of 2.4×10^{6} m/s has a de Broglie wavelength of

A. 1.6×10^{-20} m
B. 4.2×10^{-14} m
C. 1.7×10^{-13} m
D. 2.4×10^{-6} m

48. Applying the ideas that Compton used to find the momentum of the photon, de Broglie predicted that

A. photons must have mass
B. mass can be converted to energy
C. moving particles have an associated wavelength
D. exact photon positions are impossible to measure

49. If the uncertainty in the speed of a 400 kg space probe is 0.5 m/s, the theoretical minimum uncertainty in its position is in the order of

A. 10^{-37} m
B. 10^{-35} m
C. 10^{-33} m
D. 10^{-31} m

YOU HAVE NOW COMPLETED THE MULTIPLE-CHOICE SECTION OF THE EXAMINATION. PLEASE PROCEED TO THE NEXT PAGE AND ANSWER THE WRITTEN-RESPONSE QUESTIONS IN PART B.

PART B

INSTRUCTIONS

Please write your answers in the examination booklet as neatly as possible.

Marks will be awarded for pertinent explanations, calculations, formulas, and answers. Answers must be given to the appropriate number of significant digits.

NOTE: The perforated pages at the back of this booklet may be torn out and used for your rough work.

TOTAL MARKS: 21

START PART B IMMEDIATELY

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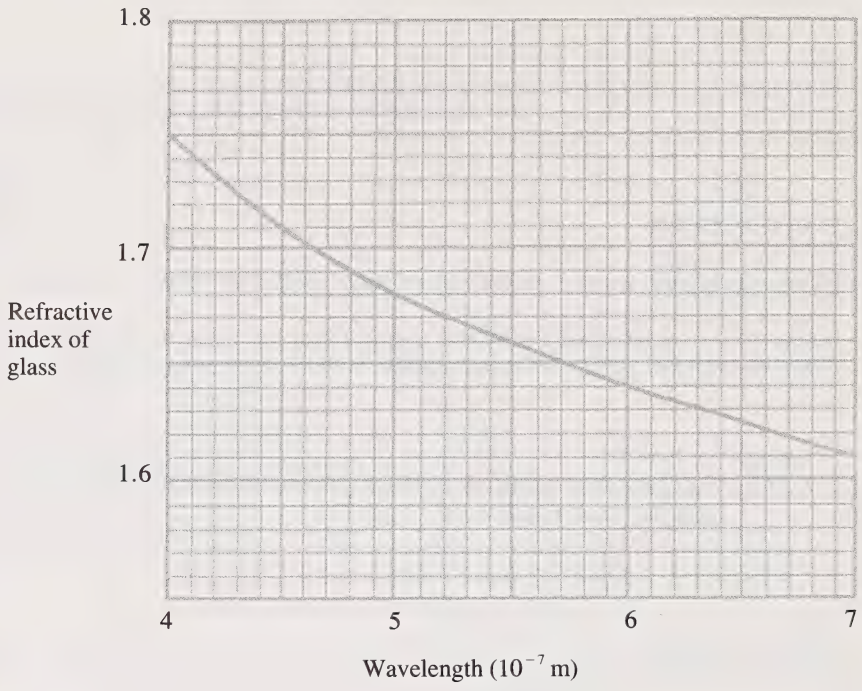
Use the following information to answer question 1.

Below is a graph of the refractive index for a particular glass as a function of the wavelength of the incident light.



1. A parallel beam of light contains two wavelengths of light, violet ($\lambda_v = 4.00 \times 10^{-7}$ m) and red ($\lambda_r = 6.50 \times 10^{-7}$ m). The beam travels from air to glass and strikes a piece of glass at an incident angle of 80.0°.

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a. Sketch a diagram of the incident and the refracted beams, indicating the angles of incidence and refraction. Label the red and the violet beams within the glass. **(2 marks)**

b. Calculate the angle between the red and the violet beams inside the glass. **(3 marks)**

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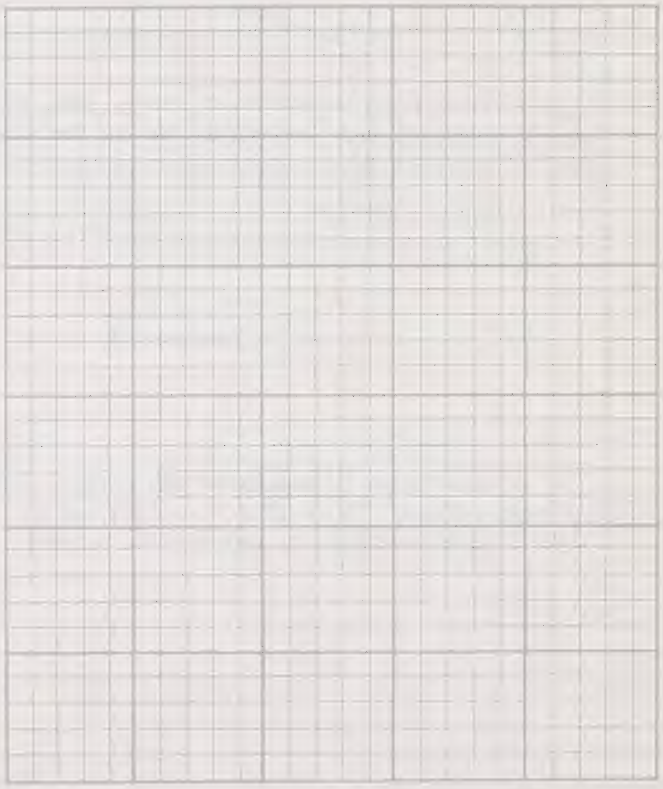
Use the following information to answer question 2.

A student measured the voltage across a constant resistance while varying the current. The following results were obtained.

Current (A)	Voltage (V)
0.00	0.0
0.40	1.5
0.90	4.6
1.3	6.0
1.7	9.0
2.4	11.9

(2 marks)

2. a. Make a graph using the above data. Label the axes appropriately with the independent (manipulated) variable on the horizontal axis.



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b. Using only the graph and with NO reference to the data table, calculate the resistance. **(2 marks**

c. As an alternate method, use the data table to find the best estimate for the average resistance. **(2 mark**

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3. Light of wavelength 4.69×10^{-7} m is incident on a photoelectric surface that has a threshold frequency of 3.00×10^{14} Hz.

(2 marks)

a. Calculate the maximum kinetic energy of the emitted photoelectrons.

(3 marks)

b. Identify the assumptions made by Einstein in his derivation of the photoelectric equation, $E_k = hf - W$.

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Use the following information to answer question 4.

A radioactive isotope of cobalt emits a photon of wavelength 9.30×10^{-12} m. The cobalt nucleus contains 27 protons and 33 neutrons. The cobalt nucleus is in a crystal containing 6.02×10^{17} identical atoms. The entire crystal recoils when the photon is emitted.

This recoil of the entire crystal rather than a single nucleus is called the Mössbauer effect in honor of its discoverer, who first observed it in 1958.

4. a. Calculate the momentum of the emitted photon. **(1 mark)**

b. Calculate the extremely slow recoil velocity of the cobalt crystal. **(3 marks)**

c. What conservation law did you use to find the velocity in part b? **(1 mark)**

YOU HAVE NOW COMPLETED THE EXAMINATION. IF YOU HAVE TIME, YOU MAY WISH TO GO BACK AND CHECK YOUR ANSWERS.

(NO MARKS WILL BE GIVEN FOR WORK DONE ON THIS PAGE)

TEAR-OUT SHEET

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